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on the methods used for making histological and embryological preparations. The account here given applies, of course, to the best laboratories, but they do not all offer the same great advantages.

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THE DISTRIBUTION OF VEGETATION IN PORTIONS OF NEVADA AND ARIZONA.

BY W. J. HOFFMAN, M. D.

THE flora of Nevada may be divided into four distinct classes, namely: —

I. The flora of the mountains.
II. The flora of the foot-hills.
III. The flora of the plains.
IV. The flora of the salt marshes.

In the lower two thirds of Nevada and the northwestern portion of Arizona, from latitude 41° 40′ N., at Bull Run Mountain, southward to latitude 35° 20′ N., we have a country composed of a series of plains and deserts surrounded by a net-work of mountain chains. The more northern valleys are composed of tolerably good soil, but as we proceed southward they become more and more sandy, and contain a greater amount of saline ingredients. There is every evidence that many of these basins were at one time inland seas, but owing to the rapid evaporation and absence of aqueous precipitation, they have in the greater number of instances become dry, leaving their solid ingredients as the soil of the deserts, as in Diamond Valley, Death Valley, etc., or there may still remain sufficient moisture to cause salt marshes, as Armagosa Desert and that at Silver Peak which covers an area of only about eight or nine hundred square miles of mud and salt. A great deal of the alkalinity of some regions is derived from the mountains. During the disintegration of feldspathic rocks, the soluble salts are slowly carried down to add to the sterility of the valleys. Rain seldom falls on the plains, but the more prominent peaks are subject to showers nearly every afternoon. Peaks whose altitude exceeds that of the timber-line are most frequently visited. The causes are, the air becoming heated on the deserts (as in Death Valley we recorded 120° in the shade at from two to half past three o'clock) rises towards the cooler summits of the mountains, when condensation of vapor terminates in precipitation, the heavy clouds charged with electricity hanging over the mountains for an hour or two, usually disappearing before sunset. The rain seldom reaches the base, as the parched sandy soil absorbs it before it descends half-way down to the foot-hills, except in case of cloud-bursts when the water tears up a new channel and rushes out over the desert to sink at once in the soil. These storms do not affect the atmosphere of the plains perceptibly. Differences of wet and dry bulb readings show variations ranging from 5° to 45° F.

The flora of that portion of Arizona under consideration may likewise be classed under the same divisions, excepting that the fourth class gradually diminishes, giving place to that of the dry sandy deserts — which we will include with the third class — of the plains in Nevada.

The following table is arranged according to the latitudes, commencing at the northernmost point (Bull Run Mountain) and running south: —

Name.	Altitude above Sea Level.	Elevation of Timber-Line.	Latitude.	Elevation of Nearest Plains.
Bull Run Mountain	8,450	8,300	41° 40′	5,800
Prospect Hill	9,650	9,400	39° 30′	6,000
Belmont	12,000	9,700	38° 40′	7,000
Mt. Nagle	11,000	11,000 [1]	37° 46′	7,200
Mt. Macgruder	11,500	11,150	37° 40′	7,200
San Francisco Mountain	13,500	12,500 13,000 [2]	35° 19′	6,500 6,800
Bill Williams Mountain	10,030	[3]	35° 13′	6,500

Mr. J. M. Coulter,[4] in his report upon the flora of Colorado, etc., says "that there is a very regular increase in the elevation of the timber-line as the latitude decreases, subject, of course, to variations when in the neighborhood of high table-lands or seas." This not only holds true in that region between the Rocky Mountains and the Sierra Nevadas, but, in taking a view of the section from Bull Run to Mt. Macgruder in Nevada, and as far as Bill Williams Mountain in Arizona, we have a barometric profile upon which not only the timber-line follows that law, but likewise different genera of plants and trees. The level of the prairie at Bull Run is 5800 feet above the sea, while at Mt. Macgruder — the southernmost point of observation in Nevada — it has risen to 7200 feet. At Bull Run the timber-line, at an altitude of 8300 feet, terminates with the upper line of the belt of *Coniferæ*, while the lower line rests upon a belt (400 feet of the vertical section) of mountain mahogany (*Cerocarpus ledifolius*), which in turn gives place at 7000 feet to the belt of *Salicaceæ.* This group terminates irregularly at the beginning of the foot-hills, at an elevation of about 6200 feet. The foot-hills are chiefly covered with *Phlox*, *Lupinus*, and *Rosaceæ*, and the plain with "grease-wood" (*Sarcobatus vermiculatus*) and "sage-brush" (*Artemisia tridentata*), the former being greatly in excess, but is gradually replaced by the latter going southward. The lines of demarcation are frequently indistinct, owing to the mingling of species of one belt with the adjoining ones, but they are plain enough to obtain an average elevation which I shall adopt in these descriptions.

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[1] The altitude of Mt. Nagle does not reach that of the timber-line.

[2] The timber-line on this mountain is irregular, approaching to within one thousand feet on the eastern side and five hundred feet on the western.

[3] Bill Williams Mountain does not reach the elevation of the timber-line.

[4] Prof. F. V. Hayden's Report, 1872, page 751.

At Prospect Hill, the timber-line has risen to 9400 feet in altitude; the belt of mountain mahogany becomes narrower, giving place at 8000 feet to the *Salicaceæ*, which belt becomes broader and terminates below at an elevation of 7000 feet. As the level of the plain is 6000 above the sea, there are 1000 feet to be accounted for. The plain contains more *Artemisia tridentata*, and *A. filifolia* in place of *Sarcobatus vermiculatus* to a very great extent, the latter being found on the lower foot-hills, above which we find but little *Phlox*, some *Lupinus*, and more *Rosaceæ* and *Compositæ.* There is here a great increase in elevation of similar species over those at Bull Run.

Again, at Belmont the *Coniferæ* end with the timber-line at 9700 feet, and where the belt of the *Salicaceæ* begins but a seam of scattering mahoganies is found, the place having been taken up by a wider belt of *Coniferæ* above and of *Salicaceæ* below. On the plains south of Belmont more saline matter is found in the soil, giving rise gradually to a more desert-like vegetation. *Artemisiæ* are less numerous, and are replaced by *Algarobia glandulosa*, the former occurring abundantly on the foot-hills, upon the upper slopes of which *Cactaceæ* now make their appearance. At Mt. Nagle and, just south of it, at Mt. Macgruder, there is little variation of elevation of the flora, so that at the latter the timber ceases to grow at 11,150 feet (covering the summit of Mt. Nagle at an altitude of 11,000 feet), the belt of *Coniferæ* running down to 8500 feet, when the belt of *Salicaceæ* occupies the space down to an elevation of 8100 feet above the sea. The belt of the *Compositæ* now rests upon one of *Yucca buccata* and *Y. angustifolia*, which, farther down on the foot-hills, is replaced by *Cactaceæ*, and on the desert by the *Artemisia triden-*

tata and *Algarobia glandulosa* in excess. The plains and salt marshes in this vicinity are at an elevation of 7200 feet above the sea, and gradually slope towards the Colorado River, until we reach the deserts just north of that valley, where the average elevation is 1400 feet. This descent is so rapid, comparatively, that as we proceed southward, zones or belts of vegetation are passed through — underlying that upon the salt deserts at Macgruder — not encountered heretofore, and which partake of a sub-tropical nature in predominating species, that is, *Cactaceæ*, such as *Echinocactus*, *Mamillaria*, *Agava*, and *Larrea Mexicana.*

Southward and eastward of the Colorado River, in following this elevated portion of the country, we encounter the Colorado Plateau, having an elevation of from 6000 to 6700 feet. Upon this we have San Francisco Mountain and Mt. Bill Williams. Upon the former, the timber-line rises to within one thousand feet of the summit upon the eastern side (12,500 feet) and to within five hundred on the western (13,000 feet).

The belt of *Coniferæ* extends down to the base of this mountain as well as on Mt. Bill Williams,[1] and is subdivided into two divisions, the upper being composed chiefly of *Pinus brachyptera* and *P. edulis* Engelm., and the lower of *Abies Douglasii* and *Juniperus occidentalis.* Throughout the ravines and moist depressions we now find *Fraxinus velutinus* common; and scarcely any *Populus monilifera.* Around the base of both mountains we find *Quercus Gambelii* extending up the eastern slopes but *not* upon the western.

After leaving the plateau, going southward, and again descending to an elevation of 3500 feet, we meet the belts of sub-tropical species which occur above the plateau (in Southern Nevada) at a corresponding place, allowing the increase of elevation which it gains in this distance proportionately.

As we descend toward the valley of the Rio Gila, *Cactaceæ* predominate, nine species having been identified, not embracing varieties which are undoubtedly present and which could have been detected upon closer examination. Farther west, including the Mojave Desert, and northward as far as Vegas Valley, we find this thorny vegetation to a great extent; and in various depressions and ravines occur *Eriodiction*, *Algarobia*, and *Prosopis.*

There is a gradual elevation, as we proceed southward, of all these zones or belts of vegetation, which may at times consist only of a single species (*Cerocarpus ledifolius*), at others of a genus (*Pinus*), but more frequently of a variety of genera or even of families. In the northern portion of Nevada a single genus of plants is often found occupying a large extent of rolling country, when, as we reach the limit of distribution, a few yards farther on will find us in another and a distinct group. At some points, again, the line of demarcation between the desert flora (*Artemisia tridentata*) and that of the foot-hills (*Sarcobatus vermiculatus*) is so sharply drawn as to be visible from any elevated point of observation, this being apparent on account of the difference of the color of foliage.

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[1] For information regarding San Francisco Mountain I am indebted to Mr. G. K. Gilbert (Geologist Geolog. and Geograph. Exp. for Explor. Nevada and Arizona, 1871–2, Lt. G. M. Wheeler, Corps of Engineers, commanding).

Again, we find areas over which the vegetation is as yet an indiscriminate mingling of genera and families, but over which the *Compositæ* appear to have the " balance of power."

This peculiar distribution is apparent over all that portion of Nevada and Arizona before named, but as we go southward we find each genus or family of plants or trees gradually rising in elevation, and if we do not discover all the preceding individuals, we find representatives belonging to the same genera or families replacing them at those altitudes, which in turn give rise to other forms, to other types, or a new belt, occupying that space caused by the elevation of the belt above. This succession is visible in following the elevated mountain regions of the American continent, but is modified in the vicinity of seas, as at Panama. As the vegetation is thickest and most luxuriant in the tropics, it forms a covering which decreases in quantity and growth towards either pole. The equatorial zone is the home of ferns and palms, which gradually lose predominance in advancing towards the temperate zones as they do in ascending the mountains situated in the equatorial regions. That at great altitudes the belts of vegetation and timber are again met with, which ascend from both the northern and southern parallels of latitude, is verified by Von Humboldt,[1] who says, " The great elevation attained in several tropical countries, not only by single mountains but even extensive districts, enables the inhabitants of the torrid zone to behold also those vegetable forms which, demanding a cooler temperature, would seem to belong to other zones. Elevation above the level of the sea gives this cooler temperature even in the hottest parts of the earth, and cypresses, pines, oaks, berberries, and alders nearly allied to our own cover the mountainous districts and elevated plains of Southern Mexico and the chain of the Andes at the equator."

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[1] Aspects of Nature, etc., Alex. von Humboldt. Trans. by Mrs. Sabine, Philadelphia, 1849, pages 245, 246.

This rule is also followed by representative species of birds, taking, for example, the ruby-throated humming-bird (*Trochilus colubris* Linn.), which is found from latitude 61° N. to Terra del Fuego, the southern remnant of the American continent, while it has been observed in the tropics at an altitude of 14,600 feet. I have observed it in Nevada, latitude 38° N., at an elevation of 9700 feet (timber-line), and it appears thus to be found nearly everywhere within that line, at which phenogamous vegetation ceases to exist.

Species found in Mexico are also found at an altitude in the tropics at which the same temperature and the same belt of vegetation occurs, which would place an outside limit of altitude at about 10,000 feet. M. Becquerel[1] says, "In the equatorial zone no change is observed in the vegetation from the level of the sea to the height of 600 metres (1969 feet), and beyond this even to an altitude of 1200 metres (3937 feet) we still recognize the flora of the tropical zone."

It is apparent, then, that in the distribution of a flora from north to south, or in equal directions (or nearly so) from the equator, there is a downward tendency as the latitude increases. This zone of vegetation being divided into successive layers, vertically at the torrid zone, which, as they rise in altitude, spread their termini over a section of country where they descend, give rise to a succession of changes from a torrid to an arctic flora. This zone forms an arch, when viewed in a barometric profile, from the northern to the southern hemisphere, having the greatest depression over the equatorial region.

That the regularity in location of these various belts is governed by climatic or meteorological laws, modified to some extent by geological causes, is apparent and undoubtedly true, but regarding the local distribution throughout any one of these belts there are slow changes, as on some of the deserts in Arizona or in the salt marshes of Nevada.

On the Gila Desert, as elsewhere, we observed the remains of an undergrowth of acacias (*Algarobia glandulosa*) which were destroyed by the encroaching *Cereus giganteus*, and here the law of *mutual repulsion* is forcibly illustrated. Dr. J. M. Bigelow[2] noticed the same fact in the valley of Bill Williams Fork, and says "that it [Acacia] forms a shelter for the propagation of the *Cereus giganteus* of that region. Every young *Cereus* is protected and fostered by this tree until the cactus attains the size and hardihood that enables it to withstand the war of elements waged against it, when it ungraciously spurns its protector, ultimately destroying it, as we saw in numerous instances on our journey."

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[1] In Smithsonian Report, 1869, page 401. (Translation.)

[2] Pacific R. R. Report, vol. iv., page 21. (No. 2 Botany.)

That geological and climatic influences and effects modify and in time alter the flora of a district is perceptible in the salt marshes. Here the lower forms of vegetation flourish in luxuriance, especially the *Chenopodiaceæ*, in which the higher types seem unable to exist on account of the strongly alkaline soil, and even in waters strongly impregnated with salt, forms exist which retain these places in spite of the force brought to bear upon them from the invading species which perish not from a "mutual repulsion and subjection," but from the alkalinity of the soil itself.

Mr. Lester F. Ward proposes "what might be called the law of *mutual repulsion*, by which every individual, to the extent of its influence, repels the approach of every other and seeks the sole possession and enjoyment of the inorganic conditions surrounding it; this mutual repulsion results at length in a statical condition which is always brought about through the action of the vital forces themselves, and which, as soon as reached, determines absolutely the exact place and degree of development of each species and each individual."

This is at present not the case in the salt marshes, but, when an accumulation of organic and silicious matter is the result, through the decomposition of the plants and the dust from surrounding sources, these lower types lose their predominance, and higher types replace them. This will ultimately be the result, as there is no aqueous precipitation, and the constant evaporation from the marshes will leave them nothing but alkaline deserts.

Upon the foot-hills in the upper portion of Nevada different species of plants occupy distinct patches, but it is apparent that there are changes going on, and that in time some will be destroyed, giving place for hardier varieties. Mr. Ward further says, "Each species is the perpetual and inexorable antagonist of every other. The 'struggle' is not alone 'for existence,' it is also for *space*. . . . . But the first principle, as in the rest of nature, is force. Each one encroaches with all the power of vegetal growth upon its neighbors." Where an area of vegetation has not been disturbed by mechanical or agricultural causes, the species and genera growing thereon are to all appearances occupying their limit of growth and local distribution, as over various valleys and low elevations in Northern Nevada. "But let these statical conditions be once changed, ... and this equilibrium is immediately disturbed. The chained forces are set free; a general swarming begins; some individuals are destroyed, others are liberated; each pushes its advantage to the utmost, and all move forward in the direction of least resistance, till at length they again mutually neutralize each other, and again come under new conditions and modified forms, into the former state of quiescence." [1]

There has been great difficulty experienced in some of the fertile valleys of Nevada and California in attempting to prevent the rapid encroachment of native plants upon partially cultivated and irrigated patches of soil. They are stronger in vegetal power, and in a short time depauperate and stunt the introduced cereals and garden vegetables.

These vegetal "struggles for space and existence" are stronger and the results more perceptible in the tropics than elsewhere; rising in altitude with the superlying belts of vegetation, they decrease until the region beyond the timber-line is reached, in a similar manner as when we proceed towards either pole in almost a fixed proportion to the latitude. This is caused by a variety of influences, prominent amongst which are

(1.) The presence of saline matter to such an extent as to cause the destruction of any but the lower types of vegetable life, — *Chenopodiaceæ.*

(2.) In the sub-alpine belt or latitudes, where the *Coniferæ* predominate and where there is a corresponding temperature unfavorable to other types generally, and

(3.) Beyond the timber-line or at extremely high latitudes, where the superincumbent mass of snow in winter and the extremely short temperate season prevent the growth of almost anything save lichens and mosses.

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[1] Mr. L. F. Ward, Popular Science Monthly, October, 1876.